Meta-analysis of 4R Nitrogen Management on Direct Nitrous Oxide Emissions from Croplands in Cold Climate

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Manitoba Agronomist Conference (MAC)
December 2023

Objectives

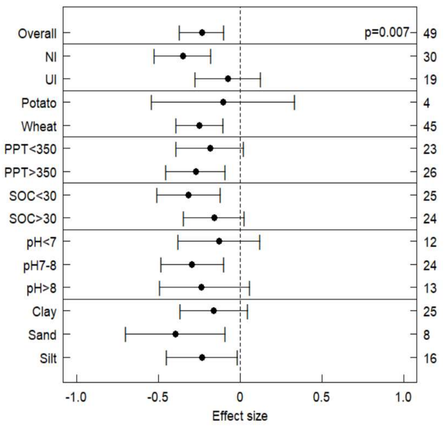
- To determine the impact of Enhanced Efficiency Fertilizers on N_2O emission .
- To compare the effect of fall and spring N application on N_2O emissions.
- To examine impact of methods of fertilizer placement on N_2O emissions.

Background

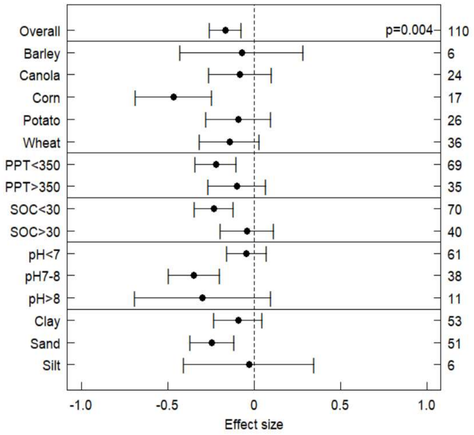
- Nitrous oxide emissions are largely attributed to application of nitrogen fertilizers and animal manures.
- Manitoba, Saskatchewan and Alberta, account for nearly 80% of all N fertilizers used, resulting in 71% of N_2O emissions from the agricultural sector in Canada.
- Use of 4R Nutrient Stewardship, i.e., application of right source at right time, right rate, and place, is an effective way to reduce N_2O emissions, whereas its overall impact for croplands in cold climate remains unknown.
- Enhanced efficiency fertilizers (EEFs) with nitrification inhibitors (NI) have the potential to reduce N_2O losses.

Methodology

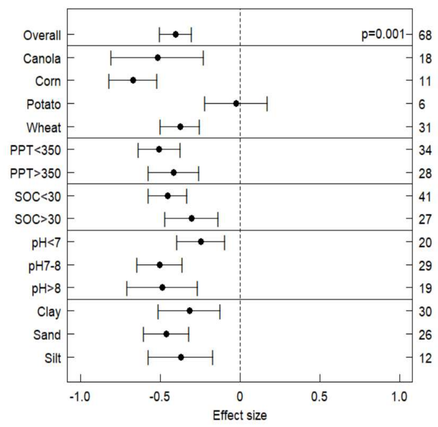
- Data were collected from field experiments conducted in Western Canada and regions with similar climatic conditions (Köppen Dfb, warm summer humid continental climate).
- Effect size was calculated as: ln RR = $\ln(x_t/x_c)$, where x_t and x_c are the mean values of cumulative N_2O emissions (kg N_2O-N ha^{-1}) for treatment and control, respectively. The variance of effect size was calculated in R.
- The missing values of standard deviation were estimated using "metagear" package and meta-analysis was carried out using "metafor" and "metaforest" packages.
- Random-effect model was used at 95% confidence interval to examine the significant effects of mean of effect size.



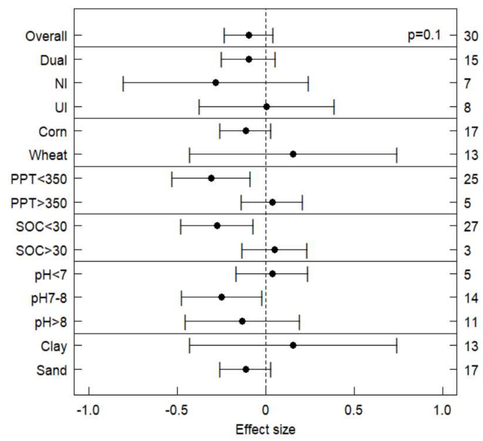
a) Urea: Urea+ Inhibitors (Treatment)
Conventional Urea (Control)



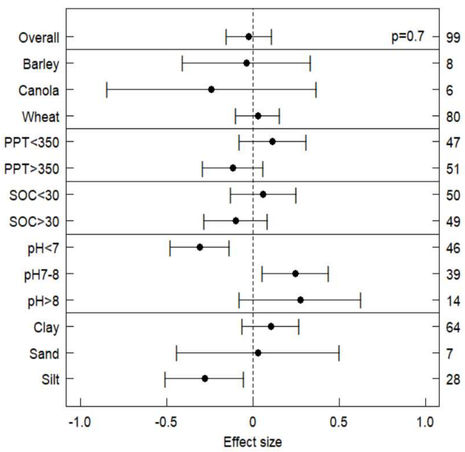
b) PCU: PCU (Treatment)
Conventional Urea (Control)



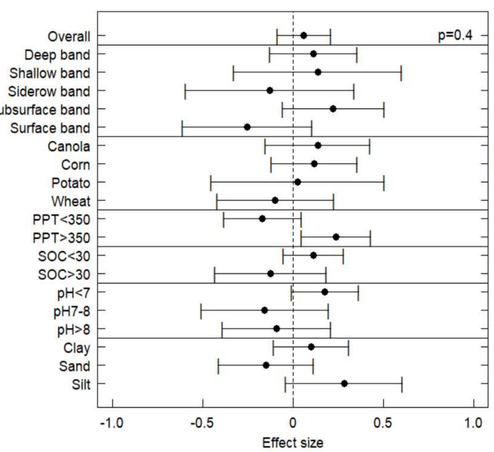
c) Dual: Dual (Treatment)
Conventional Urea (Control)



d) UAN: UAN+ Inhibitors (Treatment)
UAN (Control)



e) Time: Fall (Treatment)
Spring (Control)



f) Placement: Band (Treatment)
Broadcast (Control)

Figures: Effect of fertilizer source, timing and placement on soil N_2O emissions under different categories. Number of observations are shown on the right axis. Error bars represent 95% confidence intervals.

Results and Conclusion

- **Source effect**: Compared to conventional urea, use of inhibitors overall reduced N_2O emissions by 23%, with the effect being significant when precipitation is greater than 350 mm, soil organic carbon is less than 30 g/kg, pH is 7-8, and soil texture is sand or silt. Use of PCU significantly reduced N_2O emissions at precipitation less than 350 mm, soil organic carbon less than 30 g/kg, pH 7-8, and soil texture is sand. Dual inhibitors resulted in an overall N_2O reduction of 10%. Use of inhibitors with UAN did not show an overall impact. However, inhibitors reduced N_2O emissions from UAN when precipitation is less than 350 mm, soil organic carbon is less than 30 g/kg and pH is 7-8.
- **Timing effect**: No significant difference in overall N_2O emissions between fall and spring application. However, fall application reduced N_2O emissions under specific conditions, namely, when soil pH is lower than 7, and soil texture is silt.
- **Placement effect**: Banding of fertilizer did not significantly affect the overall N_2O emissions, but increased N_2O emissions when precipitation is greater than 350 mm, and soil texture is silt.

Acknowledgement

This study is funded by the NSERC / Western Grains Research Foundation / Fertilizer Canada 4R Senior Industrial Research Chair Program.

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